An inaugural essay
on
Respiration.

Submitted to the examination
of the
Reverend John Andrews. D.D. Provost.
The
Trustees and medical Professors of the
University of Pennsylvania.
For the Degree of Doctor of Medicine
On the day of one
thousand eight hundred & eleven.

By John D. Perkins of
Maryland.

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An essay &c. —

The difficulty in selecting a subject for an inaugural dissertation will not be thought inconsiderable by those who have had occasion for making the trial. — The causes from whence originate this difficulty are as numerous as the various sources of error. — One, the most common, is the almost impossibility of advancing any thing new. — and a second may be, that to write with ease and perspicuity on subjects that might be improved requires no inconsiderable portion of talent and a habit of committing our ideas to paper. —

The first of these I shall cease to regret as a source of uneasiness; for we are told "that there is nothing new under the sun". — and the grievance arising from the second will soon cease to give disturbance, when I reflect how little will be expected from a young man newly entering the field of science, whose genius if he possesses any has not yet been matured by experience or extensive observation. —

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An attempt to make any improvement on the opinions of men of science, particularly on the function of the Lungs, might be considered unimportant - but when we reflect that ideas however sublime are liable to be stained with error, and that many of the functions of the human body still remains inexplicable or very imperfectly known, any effort to establish the truth, no matter how feble, should not be condemned by an illiberal censure. —

The true Physiology of the Lungs has been thought to be ascertained to such an absolute certainty that few of the modern writers have attempted any improvement, barely contenting themselves by making extracts and exclusively following the opinions of others, who they had conceived to have treated the subject with the greatest success. But during the course of the following enquiry I shall attempt such a statement of facts, as will tend to prove that error has not only been countenanced but generally committed, in almost every attempt that has been made to improve this part of science. —

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It is true that no subject ever engaged so much the attention of Medical Philosophers as that of which we are going to treat; and it is amusing to look over the different theories which for centuries have entertained the Medical World - while some are to be admired for ingenuity alone; others, less instructing, have confused the subject by drawing mistaken inferences from premises originally good. —

I shall leave unnoticed many opinions, which although once were in high estimation have not the least shadow of truth much less do they contribute to the explanation of the animal functions. —

The manner in which respiration was performed could not fail to interest the earliest medical enquirers, and men of abilities, have exercised great ingenuity in endeavouring to account for it. — Among the numerous writers on this subject, we find the celebrated Boerhaave whose theory was advocated by men of the most lively genius; and if reputation alone would entitle

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an opinion to credit, there is none that would be more acceptable than that of the wise the illustrious Boer-haave. —

There are many opinions which at first appear to be both ingenious and plausible, but when minutely examined, error, that too often concealed visitor, will be found "disfiguring the face of wisdom" — this I am persuaded will be the case, on entering an impartial in-vestigation of the theory of Boerhaave, and will be suf-ficient to prove that the ideas of great men are not always great. —

The opinion of Boerhaave on the alternate rising and falling of the chest is briefly this — he supposes that a smaller quantity of blood is transmitted to the left ventricle of the heart in consequence of the distended lungs pressing on the pulmonary veins; hence he concludes that less blood will circulate through the vessels supplying the cerebrum and cerebellum; in consequence of which, there will be a paucity in the secretion of nervous fluid — hence the Diaphragm

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and intercostal muscles will be relaxed, but no sooner does the blood flow in a more plentiful stream to the brain, than the secretion of nervous fluid becomes more abundant, and the inspiratory muscles being strengthenid, immediately renew their action. —

A reflection naturally arises, which causes us at once to withold our assent to this opinion — If the increase or diminution of a nervous fluid would thus operate on the inspiratory muscles, why does not the same cause affect the heart, as well as every other muscle of the body? as far as we have been able to ascertain, the nerves operate alike on all muscles, and a change in the operation of one, we should think would produce a similar change in those of others: — but we have still more powerful reasons for rejecting this opinion. It has been intimated that Boerhaave supposed, "a slow circulation through the pulmonary vessels, was caused by the pressure of the expanded lung" now experience directly contradicts this assertion, for it is known that an injection will pass through

* Note

When the lungs are collapsed, the vessels must be corrugated, in order to follow the cellular structure of the lungs - consequently an injection will find more difficulty in passing thro' a curved tube than a straight one.

the vessels of the Lungs with more facility when the chest is inflated with air than when the lungs are collapsed.*

Again, if this theory were correct, the force of the heart would always be less when the Lungs were inflated, and the weakness would be observable in the pulse - which however is not correct - neither is there any irregularity in the pulsations of the heart and arteries either during inspiration or expiration. Lastly - if by an exertion of the will, we refrain from breathing for some time, the moment we cease the exertion the inspiratory muscles renew their action with redoubled vigour, which could not possibly be the case if Boerhaave's theory were correct for immediately the air begins to inflate the lungs, according to his idea, the blood would circulate slowly to the diaphragm and intercostal muscles, and they would be unable to renew their action on account of a scanty supply of nervous fluid.

Another theory not less ingenious, but certainly more erroneous than the one we have noticed, has not long since been advanced by a writer in the Edinburgh

medical essays, who perceiving the very striking objections to the theory of Boerhaave & some others, has attempted an explanation of the alternate rising and falling of the chest, in a manner which the author thinks less liable to error; but if I am not mistaken his ideas are more remote from truth than any that has yet been advanced.

The writer begins by commenting on the wisdom and goodness of the Supreme Being for having so wisely framed our system, that the diaphragm "the great muscle of in-spiration" should be supplied with nerves from a distant origin - and he demands with apparent exultation, why the phrenic nerves are not formed from the plexus of the par vagum? The writer observes, that the phrenic nerves originate from the middle cervical nerves, and, that they travel down through the chest & lie so exposed that they are liable to compression by every dilation of the thorax - Having advanced thus far, the author thinks that respiration may be explained in the following manner. - At the end of expiration when the lungs are supposed to be collapsed, the nerves of the

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diaphragm are supposed to be free from compression, and the nervous fluid, or whatever is communicated to the muscular fibres finds an easy passage to the muscles of inspiration, which latter immediately contract and enlarge the thorax, whence the air rushes in; but no sooner does the pressure from the inspired air become anywise great than the nervous influence over the diaphragm ceases, this muscle is relaxed and expiration follows of course.

The resemblance between this last theory and that of Boerhaaves, appears very striking - they both suppose the motions of the diaphragm to be influenced by an increase or diminution of nervous fluid, and that the proximate cause of this is from compression; the only difference is, that one supposes the pressure to be applied to the pulmonary veins, preventing a too copious secretion of nervous fluid - the other that it is applied to the phrenic nerves only, and that the alternate rising & falling of the chest depends on the quick or slow circulation of a nervous fluid. -

The objections to Boerhaaves theory will equally apply

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to this last, and I shall only add one more, which I consider incontrovertible – If ~~by~~ the diaphragm could be relaxed from a slight compression of its phrenic nerves, and expiration the natural consequence of this relaxation, it would be impossible by any effort of the will to retain the chest in a distended state longer than in ordinary inspiration, because the diaphragm would be immediately relaxed as soon as the inflation became any wise great. –

To attempt any farther comment on the above would be useless, as I am convinced that every one who maturely reflects on the structure of the lungs and the phenomena attending the process of respiration must be convinced that the above theory is far from being able to encounter the objections that might be urged against it. – I shall therefore proceed to the examination of those opinions that are more plausible and generally received. –

Among the many writers on the Physiology of the Lungs, there are none who stands higher in reputation

than the justly celebrated Dr Whytt, and none whose opin-
-ions have met with more general approbation; his ideas
on the process of respiration, I believe to come nearer the
truth than any that has yet been advanced; but still
I am persuaded there is room for improvement and I
hope my efforts to attain a greater perfection, will not
be condemned because my opportunities of acquiring in-
formation have not been as great as many who are both
older in wisdom and experience. —

It is to be remarked that every function of the human
body was at one time thought to be inexplicable; what
gave origin to this ominous supposition was, the inef-
-ficient and fruitless attempts that were made to
account for the various functions; most of them failing
to throw much light on the subjects. it was at length
believed that the human body was governed by a su-
-pernatural power. that all its motions were directed
by a sentient principle or a residing soul; and it
was thought beyond the reach of human understanding
to comprehend the laws of a Divine creator. — but since
those days of delusion & ignorance have passed. the

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laws of nature have been beautifully unfolded by the genius and industry of bright men, and we now have reason to believe that "there is nothing mysterious but what shall be unfolded", and that the science of Physiology will soon appear to be as simple and comprehensive as it was formerly supposed doubtful and intricate.—

We will now proceed to notice Dr Whytt's theory on the cause of respiration, and ~~will~~ take such hints from him as will serve to strengthen our own ideas.—

Dr Whytt supposes that the process of respiration is under the immediate guidance of a sensient principle and that its object is to relieve an unpleasant sensation in the chest, arising from an accumulation of blood in the lungs — that the mind in order to relieve the chest, is stimulated to act by a pressure on the sensible fibres of the lungs — that the nervous influence upon the diaphragm is thereby increased — that this muscle by its contraction dilates the thorax, — the lungs are filled with air, and thus the uneasiness is removed — when the inspiratory muscles cease to act, expiration is supposed to be the consequence of the elasticity of

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This theory appears to be very rational, but I am persuaded it has some imperfections. In the first place, I cannot reconcile the idea that any of the functions of the body are under the "guidance of an intelligent principle" - This doctrine would not accord with the common ideas of the Soul. - The soul is said to be an immortal spirit, given to man to distinguish him from the rest of the creation, to direct him in the path of virtue. But if this spirit is inherent in man from his earliest infancy, it is certainly quiescent at this immature age, because the infant cannot as yet distinguish between good and evil, consequently if the soul exists at this period, it can have no influence on the mental or bodily faculties: this then is sufficient to prove that the process of respiration cannot possibly be under the guidance of any thing but what operates both in infancy and in mature age.

I shall next proceed to notice what Dr Whytt considers to be the immediate cause of respiration. - He supposes, as we have mentioned above, that

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an accumulation of blood in the vessels of the lungs, gives rise to an unpleasant sensation and that this is the sole cause of the action of the muscles of inspiration.

That there is an unpleasant sensation can be readily granted, but that this arises from an accumulation of blood, I can by no means allow - because any obstruction to the circulation through the lungs would be marked by an obvious interruption in the pulse.. In aneurism for instance the impediment to the circulation of the blood is much less than (what Dr. Whytt would make us believe) happens at every expansion of the thorax, and yet in the aneurismal limb, a faultering or interrupted pulse is very perceptible, whilst in the operation of breathing it has never been noticed. - Another objection to this doctrine is, that when the circulation is very much increased as in high fevers - there would be such an accumulation of blood as almost to produce suffocation. but on the contrary do we not frequently observe high fevers, as in the common bilious when the breathing is not more hurried nor the uneasiness more considerable than in the ordinary healthy state?

In the breathing of air which is deleterious or which contains but a small proportion of oxigen gas - we feel a much more unpleasant sensation, which cannot absurdly be attributed to an obstructed circulation -

To conclude, it would certainly be derogating from the wisdom of the Supreme Being to suppose that he had formed a system so imperfect that its wants could not be supplied without calling in the aid of the immortal spirit, or that the lungs were so framed that an impediment to the circulation should give rise to the grand object of respiration without which we could no more live than without aliment. —

The opinions we have noticed, not appearing to give satisfactory explanations of the cause of respiration, I shall proceed after a few brief remarks to advance what I consider to be more rational and concordant with Philosophical principles. —

The necessity for a continual supply of fresh air could not long remain a secret to the philosophers of every age, but the use of which was not

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known untill the discovery of the component parts of the atmosphere. - Whilst some considered that the object of respiration was to cool the blood in the Lungs, - others that the air was deprived of its elasticity and that this was the only loss it sustained. — It is not necessary to add repeated arguments to prove that these notions are unfounded - because they have long ago been laid aside. —

The grand object of respiration is to obtain a continual supply of oxigen gas. This is now consented to by all modern philosophers - and that a continual demand for this vital fluid is the cause of the alternate inflation & collapse of the lungs appears evident from a few substantial facts. -

It has been ascertained by experiments on dogs and other animals, that they can suffer submersion much longer, after being made to breathe pure vital air, than after the inspiration of common atmospheric air — and that men after breathing oxygen gas can inspire deleterious gasses with less uneasiness

* May not some of the uneasiness which our patients suffer in an advanced stage of pulmo-nary consumption be ascribed to a scanty supply of oxigen gas. —

than after the inspiration of common air * —

That the theory I have surmised is more than probable, is substantiated by noticing the first cause of respiration.—

Much ingenuity has been displayed in endeavouring to account for the first respiration of infants. —

Some attribute the first inspiration to the pain which children feel, when they are first exposed to the air, this is said to make them cry, whilst the air rushes down during this act. —

To this opinion I have a serious objection. It is well known to Accoucheurs, that when the child is expelled and the circulation thro' the chord is continued it does not breathe, at least in many cases, makes no efforts to breathe untill the chord is compressed.— This is so well known, that Midwifes generally put a ligature on the chord soon after the expulsion of the child, provided they can see any marks of life, by the motion of the child — here although it is exposed, it does not breathe consequently the reduced air cannot be the primary cause of respiration.—

Others have proposed to account for respiration by supposing that the struggles which the child makes in its passage from the womb, forces a greater quantity of blood into the pulmonary vessels, and by its distension gives pain. this causes the child to relieve itself by elevating the thorax in an attempt to cry. — But why there should be a greater determination of blood to the lungs than to other parts of the body I am unable to conceive - and I believe the ingenious author of this opinion will find it as difficult to discover any necessity for these violent struggles - But in order to completely overturn this theory I will mention an experiment which has often been tried. — The womb of some of the inferior animals have been opened near about the time they would have had their young - and when the little animals have been taken out, they were found to breathe as regular as if they had been borne in the natural way. —

It will be unnecessary to proceed farther in the examination of different opinions - the one which I shall embrace is founded on necessity, whereas

* That there is something more than vital air which is seperated from the Placenta is obvious - the growth of the child would assuredly no more proceed, than a man could live for ever by breathing. -

it is evident, all the others I have named have been founded in accident or mechanical principles.—

The fœtus in utero is now generally acknowledged to receive its nutriment* from the mother, through the medium of the placenta and its vessels. the lungs in this state are quiescent and nearly useless, their function being entirely suspended by the office of the placenta, which latter is supposed to ~~separate~~ perform the part of a gland and supplies the blood of the fœtus with the same vital fluid that the lungs do when they are called to perform their function — To prove which it is only necessary to compress the chord and the child dies. — These facts being surmised I go on to state what I consider to be the first cause of respiration.—

Immediately after the birth of the child, when it is cut off from all communication with the placenta, it begins to feel such a sense of want, on account of the oxigen being nearly expended in the system, that it involuntarily elevates the chest in order to relieve the painful sensation. when the lungs are filled with air and it has no longer become useful, it is

expelled simply by the resiliency of the cartilages of the ribs. — In this same manner, I believe that respiration continues thro' life - the same stimulus which was the first cause of inspiration continues to act through life and compells us to relieve our wants - Altho' in ordinary respiration we are but little sensible of any uneasiness, yet we may soon be convinced of the truth of the above opinion, by ceasing to breath for a few moments, when we involuntarily exercise the muscles of inspiration. —

However different the opinions may be with respect to the first cause of respiration, it is now universally agreed that its object is the acquirement of oxigene gas and to discharge from the blood what would be injurious if retained. — Without delaying to notice the different hypotheses on this subject I shall adopt the opinion of Girtanner, who supposes that oxigen furnishes to the whole system the principle of irritability.

It is true that there has been many ingenious arguments & experiments made, in order to disprove this supposition. — Among the experimenters on this subject we find the celebrated Abernethy, whose

candour and abilities are at all times to be respected. but we must take the liberty to discredit the conclusions he has drawn from experiments made on the detached limbs of animals - for they can by no means throw light, in explaining the functions of the living body. Mr Abernethy thinks one of his experiments very conclusive - he put the detached limb of a frog into an exhausted reciever, and found that it discovered signs of life equally as long as one which had been exposed to the open air - but this ~~serves~~ proves nothing we cannot suppose that the leg of a frog could have any action on the air - and the gradual extinction of life in that part of the frog under the exhausted reciever serves to prove, that the principle of irritability can exist in those animals long after death, and that the gradual extinction of life is owing to the consumption of oxigen by degrees.

I have now concluded my observations on the theory and cause of respiration. - I should have proceeded to examine the different opinions, on the changes which take place in the system in consequence of

respiration, but as the time allowed me to write a dissertation would not admit of this, I shall be content to make a few extracts from the theory of Dr. Murray whose ideas perfectly accord with my own ...

all parts of the body and products of the system are formed from the blood. Its expenditure is constantly supplied by the chyle. The peculiar character of animal matter with regard to composition is a large proportion of nitrogen and a smaller proportion of carbon. It may therefore be inferred, that in the extreme vessels, where the animal solids and fluids are formed, the general process will be, the seperation from the blood of those elements of which animal matter is composed; and of course that carbon which enters more sparingly into its composition will exist in greater quantities in the remaining blood. This is supposed to be the general nature of the conversion of arterial into venous blood. Nitrogen, hydrogen and other elements are spent in the formation of new products, and the proximate principles of the blood, probably the crassamentum chiefly, remain with an increased proportion of carbon. In this state it is exposed, under a very extensive surface to the

atmospheric air in the Lungs, the oxigen of which ab-
-stracts its excess of carbon, and forms the carbonic acid
which is expired.— At the same time another change
takes place to serve a different purpose. A supply
of oxigen seems required to support the necessary actions
of the system: a quantity of it is therefore absorbed in
the lungs and expended in the extreme vessels. The
combination of these changes, of the abstraction of carbon
by the attraction exerted to it, by the oxigen of atmos-
-pheric air, and the absorption of another portion of oxigen
with perhaps a small quantity of nitrogen, constitutes
the conversion of venous into arterial blood. —

From this view, we perceive the final purpose of
the process of respiration. In the extreme vessels the
different constituent principles of the blood, are ex-
-pended in the nourishment of the solid fibre, in the
formation of secreted fluids, and, perhaps, in the support
of the living powers. — Carbon is the least of these
principles that are expended in the formation of the
solids and fluids, consequently it must be in lar-
-ger proportion in the blood after it has undergone
these changes. — It is evident therefore that to

preserve the due proportion and prevent it from accumulating, it must be consumed by some other process. Hence the necessity of the application of oxigen to the blood in the lungs, and the origin of carbonic acid which is uniformly expired. —

We thus too trace the process of animalization from its first step - the reception of the aliment to its completion. — All animals live directly or indirectly on vegetable matter. — The principle difference in the composition of vegetable and animal matter is, in the former containing a larger proportion of carbon. — Respiration is the function by which this difference is established. The aliment received into the stomach is soon formed into a fluid capable of assimilating with the blood. It is conveyed ~~to the~~ lungs and there loses a part of its carbon, or is partially animalized. It is then distributed thro' the system & in the extreme vessels along, with some carbon parts with so much hydrogen oxigen, ~~nitrogen~~ & other elements as still to leave the carbon predominant. — By these reciprocal changes the conversion of vegetable into animal matter is effected. —

animal heat. This has been attributed to a great many causes, as combustion, electricity, friction, fermentation & phlogiston. — It would require but little reflection to be convinced, that none of these are the cause of animal heat — the lungs when the process is supposed to go on, would certainly be much warmer than any other parts of the body. —

It is to Dr Crawford that we are indebted for a compleat elucidation of this subject. The Dr has ascertained by experiment, that arterial blood has a greater capacity for heat than venous — his theory of animal heat is as follows. — In expiration a quantity of oxigen from the atmospheric air combines with carbon to form carbonic acid — caloric is at the same time extricated in consequence of this combination. — the blood at the same time is changed from venous into arterial, and by this change acquires an increased capacity for caloric. It therefore takes up the caloric that has been extricated, and an increase of temperature is thereby prevented. The arterial blood is immediately carried in the course of the circulation to

the extreme vessels, where it is gradually changed into the venous state - The caloric is slowly seperated during this change - and thus may be explained the uniformity of temperature. —

There has been some objections to this doctrine of animal heat - for instance, it has been said that the heat of the lower extremities is very much increased in a short time after an operation for the popliteal aneurism - but I think this may be satisfactorily accounted for.- When the great artery of the leg is tied, the blood has a centrifugal direction. It is driven into the smaller arteries on the surface of the limb, and a temporary inflamation is excited - this I think is sufficiently established by the heat of the limb becoming natural in a few days. —

Again. It has been observed that the heat of the body is less in old people "altho' they respire as often".- This so far from disproving our doctrine of animal heat tends to support it.- In old people, the circu=lation is more languid - consequently, the arterial

is not so soon changed in to ~~the~~ venous blood, and the caloric is seperated more slowly. —

It has been said that different stimuli increase the heat of the body, as the aliments, drinks, passions of the mind &c. but this does not discredit our theory because all stimuli increase the circulation, consequently the conversion of venous into arterial blood is more rapid - and in proportion as this change is more or less rapid will be the generation of animal heat. —

With this I finish my essay. The imperfections I am confident must be numerous - but I hope the shortness of time allowed me to write will be sufficient apology for all inaccuracies. —

It only remains for me to return my sincere thanks to one & all of the Professors of the University of Pennsylvania. The instruction as well as the many favours I have received from them, will ever be held in grateful remembrance. —

Finis. —

(Rush Papers)